CLAIMS

1. A surface discharge non-thermal plasma reactor comprising:

a plurality of surface discharge non-thermal plasma reactor elements arranged in a stack;

a surface discharge gap formed via spacers disposed between adjacent pairs of said reactor elements;

wherein individual said reactor elements comprise:

a dielectric substrate;

a first polarity surface discharge electrode disposed on said dielectric substrate;

a second opposite polarity surface discharge electrode disposed on said dielectric substrate;

wherein said first and second polarity surface discharge electrodes are disposed on said dielectric substrate in a pattern providing a surface discharge sufficient to selectively control production of nitric oxide from a nitrogen-containing gas stream being treated in said reactor.

2. The surface discharge non-thermal plasma reactor of claim 1, wherein said electrode pattern is a pattern sufficient to provide a surface discharge which maximizes production of nitric oxide from a nitrogen-containing gas stream.

3. The surface discharge non-thermal plasma reactor of claim 1, wherein said dielectric substrate is a dielectric plate having a first side and a second opposite side; and

said first polarity surface discharge electrode is disposed on said first side of said plate; and

said second polarity electrode is disposed on said second side of said plate.

4. The surface discharge non-thermal plasma reactor of claim 1, wherein at least one of said first and second polarity electrodes includes an electrode pattern comprising a plurality of parallel conductive strips connected at one side to a terminal lead.

5. The surface discharge non-thermal plasma reactor of claim 1, wherein at least one of said first and second polarity electrodes includes an electrode pattern comprising a solid electrode portion connected to a terminal lead.

6. The surface discharge non-thermal plasma reactor of claim 1, further comprising:

a protective coating provided over said first and second polarity electrodes.

7. The surface discharge non-thermal plasma reactor of claim 1, wherein said dielectric substrate forming said reactor elements comprises:

first and second dielectric plates each having a first side and a second opposite side, said first and second dielectric plates being disposed to have said first sides of said plates facing one another;

said first polarity electrode comprising a center electrode sandwiched between said first sides of said first and second dielectric plates; and

said second opposite polarity electrode comprising outer electrodes being disposed on said second opposite sides of said first and second dielectric plates.

8. The surface discharge non-thermal plasma reactor of claim 1, wherein said reactor element comprises a co-planar surface discharge element wherein:

said dielectric substrate comprises first and second dielectric plates;

said first polarity electrode being disposed on a first side of said first dielectric plate and said second opposite polarity electrode being disposed on said first side of said first dielectric plate;

wherein said second dielectric plate includes a first cutout region disposed at a first end of said second dielectric plate suitable for attachment of a first electrical busline and a second cutout region disposed at a second end of said second dielectric plate suitable for attachment of a second electrical busline; and

wherein said first and second dielectric plates are laminated together to provide said co-planar surface discharge element.

9. The surface discharge non-thermal plasma reactor of claim 1, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise an alternating series of positive and negative surface discharge gaps.

10. The surface discharge non-thermal plasma reactor of claim 1, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise all positive surface discharge gaps.

11. The surface discharge non-thermal plasma reactor of claim 1, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise all negative surface discharge gaps.

12. A combustion exhaust treatment system comprising:

an air supply and a power supply connected to the surface discharge non-thermal plasma reactor of claim 1;

a hydrogen source for supplying hydrogen to an exhaust stream of said surface discharge reactor to generate an ammonia containing exhaust stream via a first catalyst; and

a second catalyst connected to a combustion device for receiving a combustion exhaust stream and further connected to said ammonia-containing exhaust stream;

wherein during operation, an air stream is treated in said surface discharge non-thermal plasma reactor to generate a surface discharge NO-containing exhaust;

said surface discharge NO-containing exhaust is combined with hydrogen from said hydrogen source and fed to said first catalyst to generate ammonia;

said ammonia is fed into said second catalyst to be used as a co-reductant for treating said combustion exhaust stream;

said combustion exhaust stream being treated in said second catalyst to provide a catalyst treated exhaust stream comprising N_2, H_2O, CO_2, and O_2.

13. The combustion exhaust treatment system of claim 12, wherein said electrode pattern is a pattern sufficient to provide a surface discharge sufficient to maximize production of nitric oxide from a nitrogen-containing gas stream.

14. The combustion exhaust treatment system of claim 12, wherein said dielectric substrate is a dielectric plate having a first side and a second opposite side; and

said first polarity surface discharge electrode is disposed on said first side of said plate; and

said second polarity electrode is disposed on said second side of said plate.

15. The combustion exhaust treatment system of claim 12, wherein at least one of said first and second polarity electrodes includes an electrode pattern comprising a plurality of parallel conductive strips connected at one side to a terminal lead.

16. The combustion exhaust treatment system of claim 12, wherein at least one of said first and second polarity electrodes includes an electrode pattern comprising a solid electrode portion connected to a terminal lead.

17. The combustion exhaust treatment system of claim 12, further comprising:

a protective coating provided over said first and second polarity electrodes.

18. The combustion exhaust treatment system of claim 12, wherein said dielectric substrate forming said reactor elements comprises:

first and second dielectric plates each having a first side and a second opposite side, said first and second dielectric plates being disposed to have said first sides of said plates facing one another;

said first polarity electrode comprising a center electrode sandwiched between said first sides of said first and second dielectric plates; and

said second opposite polarity electrode comprising outer electrodes being disposed on said second opposite sides of said first and second dielectric plates.

19. The combustion exhaust treatment system of claim 12, wherein said reactor element comprises a co-planar surface discharge element wherein:

said dielectric substrate comprises first and second dielectric plates;

said first polarity electrode being disposed on a first side of said first dielectric plate and said second opposite polarity electrode being disposed on said first side of said dielectric plate;

wherein said second dielectric plate includes a first cutout region disposed at a first end of said second dielectric plate suitable for attachment of a first electrical busline and a second cutout region disposed at a second end of said second dielectric plate suitable for attachment of a second electrical busline; and

wherein said first and second dielectric plates are laminated together to provide said co-planar surface discharge element.

20. The combustion exhaust treatment system of claim 12, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise an alternating series of positive and negative surface discharge gaps.

21. The combustion exhaust treatment system of claim 12, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise all positive surface discharge gaps.

22. The combustion exhaust treatment system of claim 12, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise all negative surface discharge gaps.

23. A method for fabricating a surface discharge non-thermal plasma reactor comprising:

arranging a plurality of reactor elements to form a reactor stack;

disposing said reactor elements in said stack and placing spacers therebetween to provide a surface discharge gap between adjacent pairs of said reactor elements;

forming individual reactor elements by:

providing a dielectric substrate;

disposing a first polarity surface discharge electrode on said dielectric substrate;

disposing a second opposite polarity surface discharge electrode on said dielectric substrate;

wherein said disposing said first and second polarity electrodes comprises disposing said electrodes in a pattern providing a surface discharge sufficient to selectively control production of nitric oxide from a nitrogen-containing gas stream being treated in said reactor.

24. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, wherein said disposing said first and second polarity electrodes comprises:

disposing said electrodes in a pattern sufficient to provide a surface discharge which maximizes production of nitric oxide from a nitrogen-containing gas stream.

25. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, wherein said dielectric substrate is a dielectric plate having a first side and a second opposite side;

said disposing said first and second polarity electrodes comprises:

disposing said first polarity surface discharge electrode on said first side of said plate; and

disposing said second polarity electrode on said second side of said plate.

26. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, wherein said disposing said first and second polarity electrodes comprises:

disposing at least one of said first and second polarity electrodes in an electrode pattern comprising a plurality of parallel conductive strips connected at one side to a terminal lead.

27. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, wherein said disposing said first and second polarity electrodes comprises:

disposing at least one of said first and second polarity electrodes in an electrode pattern comprising a solid electrode portion connected to a terminal lead.

28. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, further comprising:

disposing a protective coating over said first and second polarity electrodes.

29. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, wherein providing said dielectric substrate comprises:

providing first and second dielectric plates each having a first side and a second opposite side, said first and second dielectric plates being disposed to have said first sides of said plates facing one another;

sandwiching said first polarity center electrode between said first sides of said first and second dielectric plates; and

disposing said second opposite polarity electrodes on said second opposite sides of said first and second dielectric plates to provide second polarity outer electrodes.

30. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, wherein said forming said individual reactor element comprises;

forming a plurality of co-planar surface discharge elements, wherein:

said dielectric substrate comprises first and second dielectric plates;

said first polarity electrode being disposed on a first side of said first dielectric plate and said second opposite polarity electrode being disposed on said first side of said dielectric plate;

wherein said second dielectric plate includes a first cutout region disposed at a first end of said second dielectric plate suitable for attachment of a first electrical busline and a second cutout region disposed at a second end of said second dielectric plate suitable for attachment of a second electrical busline; and

wherein said first and second dielectric plates are laminated together to provide said co-planar surface discharge element.

31. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise an alternating series of positive and negative surface discharge gaps.

32. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise all positive surface discharge gaps.

33. The method for fabricating a surface discharge non-thermal plasma reactor of claim 23, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise all negative surface discharge gaps.

34. A method for treating a combustion exhaust stream comprising:

treating an air stream in the surface discharge reactor of claim 1 to generate a NO-containing surface discharge exhaust;

supplying hydrogen to said NO-containing surface discharge exhaust and passing the hydrogen and NO-containing surface discharge exhaust stream through a first catalyst to generate an ammonia containing exhaust stream;

generating a combustion exhaust stream and passing said combustion exhaust stream through a second catalyst;

passing said ammonia-containing exhaust stream through said second catalyst to be used as a co-reductant for treating said combustion exhaust stream;

wherein said combustion exhaust stream is treated in said second catalyst to provide a catalyst treated exhaust stream comprising N_2, H_2O, CO_2, and O_2.

35. The method for treating a combustion exhaust stream of claim 34, wherein said electrode pattern is a pattern sufficient to provide a surface discharge sufficient to maximize production of nitric oxide from a nitrogen-containing gas stream.

36. The method for treating a combustion exhaust stream of claim 34, wherein said dielectric substrate is a dielectric plate having a first side and a second opposite side; and

said first polarity surface discharge electrode is disposed on said first side of said plate; and

said second polarity electrode is disposed on said second side of said plate.

37. The method for treating a combustion exhaust stream of claim 34, wherein at least one of said first and second polarity electrodes includes an electrode pattern comprising a plurality of parallel conductive strips connected at one side to a terminal lead.

38. The method for treating a combustion exhaust stream of claim 34, wherein at least one of said first and second polarity electrodes includes an electrode pattern comprising a solid electrode portion connected to a terminal lead.

39. The method for treating a combustion exhaust stream of claim 34, further comprising:

disposing a protective coating over said first and second polarity electrodes.

40. The method for treating a combustion exhaust stream of claim 34, wherein said dielectric substrate forming said reactor elements comprises:

first and second dielectric plates each having a first side and a second opposite side, said first and second dielectric plates being disposed to have said first sides of said plates facing one another;

said first polarity center electrode being sandwiched between said first sides of said first and second dielectric plates; and

said second opposite polarity electrode comprising outer electrodes being disposed on said second opposite sides of said first and second dielectric plates.

41. The method for treating a combustion exhaust stream of claim 34, wherein said reactor element comprises a co-planar surface discharge element wherein:

said dielectric substrate comprises first and second dielectric plates;

said first polarity electrode being disposed on a first side of said first dielectric plate and said second opposite polarity electrode being disposed on said first side of said first dielectric plate;

wherein said second dielectric plate includes a first cutout region disposed at a first end of said second dielectric plate suitable for attachment of a first electrical busline and a second cutout region disposed at a second end of said second dielectric plate suitable for attachment of a second electrical busline; and

wherein said first and second dielectric plates are laminated together to provide said co-planar surface discharge element.

42. The method for treating a combustion exhaust stream of claim 34, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise an alternating series of positive and negative surface discharge gaps.

43. The method for treating a combustion exhaust stream of claim 34, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise all positive surface discharge gaps.

44. The method for treating a combustion exhaust stream of claim 34, wherein said surface discharge gaps formed between adjacent pairs of said reactor elements comprise all negative surface discharge gaps.